Investigating three-dimensional localised effects of age, disease and treatment on mouse bone geometry using Principal Component Analysis

Matthew Bates[1], Stamatina Moraiti[2]

1 Student, Department of Computer Science

2 PhD Student, Department of Mechanical Engineering

Osteoporosis:

The prevalence and severity of bone breakages and fractures drastically increases with age. Osteoporosis leads to increased possibility of fragility fractures.

Pre-Clinical studies:

- Murine bone models are widely used.
- Osteoporosis and treatment strategies are simulated.
- Exercise is simulated by applying in-vivo mechanical loading of long bones.
- Treatment impact on bone geometry is typically assessed as changes in averaged scalar morphometric parameters.
- However, the precision and accuracy of these studies are limited by approximations - cylindrical models.

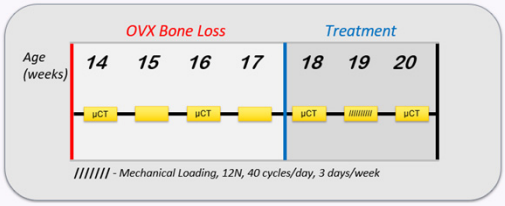
Study Aims:

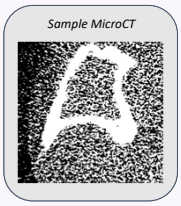
- **Use Principal Component Analysis to analyze variations in mice tibia geometry.**

0) Data

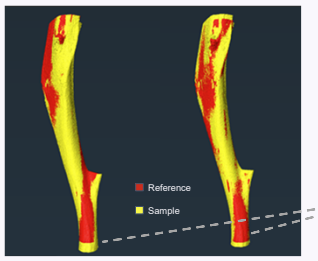
Data Collection:

- Mice are ovariectomized at week 14 to induce menopausal osteoporosis.
- Mice are subjected to mechanical loading at week 19.
- Right tibia is scanned through MicroCT.
- Longitudinal data of 6 treated mice, 2 ages.





1)Pre-Processing

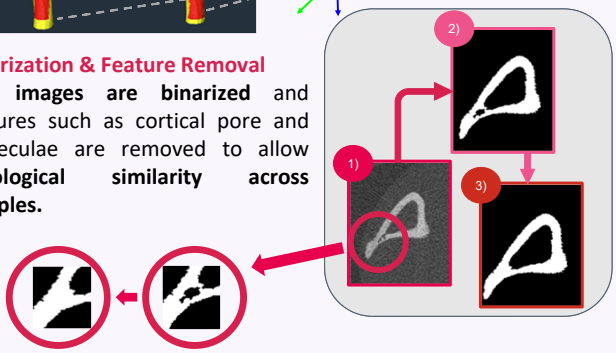


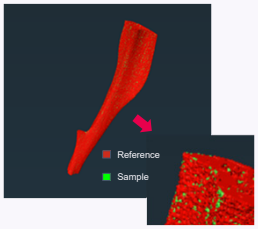
Sample registration

Performs a **rigid registration** of each sample to the reference bone, resulting in **an alignment of all samples.**

Binarization & Feature Removal

The **images are binarized** and features such as cortical pore and trabeculae are removed to allow **topological similarity across samples.**





Elastic Registration using ShIRT

- The reference image is mapped to all other image samples using elastic registration.
- The surface mesh of the reference is extracted from the binarized image.
- **The deformation field** is applied on the reference surface mesh.

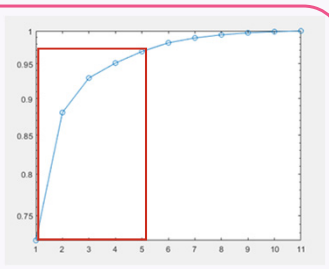
2) PCA

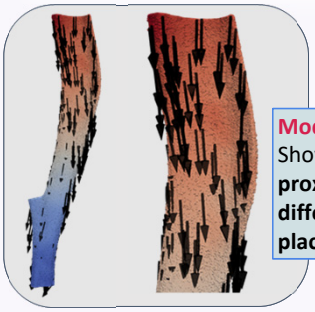
Decomposes variations into 11 orthogonal modes, each mode portraying a unique feature.
Modes are **ordered by latent** from eigen values.
Variations due to **age, growth and disease** are given by PCA modes.

3) Results & Conclusion

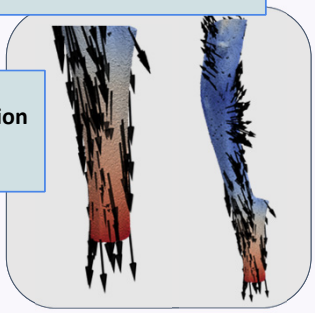
Analysis

The **first 5 modes describe 97% of total variation.**
Focus is on the **first 5 modes**, as their **variations are significant.**

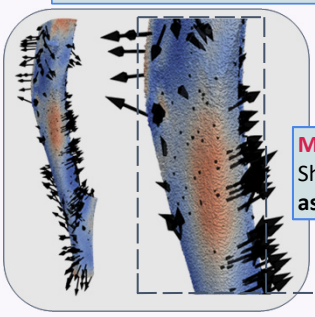




Mode 1
Shows stronger variation **toward proximal end** of tibia. Caused by **differences in growth plate placement.**

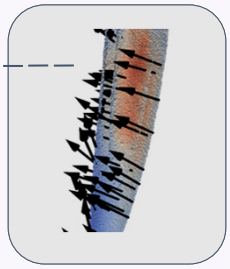


Mode 2
Shows variation of **tibia/fibula fusion** point, as well as curvature in bone geometry.



Mode 4
Shows variations at **the medial aspect of proximal diaphysis.**

X axis slice



Conclusion
PCA modes show many variations, some artefacts of methodology, however some, significantly, are not. Variations may be linked to treatment – further investigation.

In partnership with:

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